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Accident Dosimetry by Thermoluminescence of Feldspar Separated from Sands

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The present investigation was undertaken as a preliminary experiment on accident dosimetry by thermoluminescence of natural substance which can easily be found everywhere. The materials used as phosphor were quartz and foldspar, and they were separated from sands or soil by means of a magnetic method and a method of selectively staining. It has been found by this experiment that the most desirable one for the above purpose is the 140°C glow peak of feldspar because of its thermoluminescence properties, such as sensitivity, linearity and decay.

The thermoluminescence material as dosimeter for accident dosimetry has been studied in recent years[1,2,3]. Since radiation accident occurs generally at the unexpected place, one essential condition for the sample to be used as dosimeter is that one can easily find it of large amount and everywhere. Colorless minerals contained within roof tiles, such as quartz or feldspar, were used to estimate the atomic bomb radiation in Hiroshima and Nagasaki[4], and colorless minaral from pottery has been used in the study of thermoluminescence dating[5] by the authors. In view of the fact that quartz and feldspar are substance of ordinary type presents abundantly on the ground, they may be promising as thermoluminescence material for accident dosimetry.

The roof tile sample for dosimetry on the atomic bomb radiation and the pottery sample for thermoluminescence dating have been made by heating process of over 500°C whereby all trapped electrons were liberated, so that radiation effects experienced by the sample prior to the exposure of radiation to be estimated may be nearly zero as to thermoluminescence, *i. e.* the background signal is negligible. Furthermore, as the length of time elapsed since the exposure is generally very long, it requires that the mean life of trapped electron is appropriately long. On the base of these two facts, the high temperature part of the glow curve for the sample was used for the estimation of the dose absorbed in the past.

Nevertheless, in the case of accident dosimetry by natural substance, the sample shows the intense natural glow signal which has been caused by the exposure over a long period by natural radiation and this dosimetry will be restricted by the background signal. Also, time elapsed since the exposure is generally short in contrast with the above case. In view of the above facts, one might conclude that the glow peak to be used in this dosimetry must be selected from the low temperature part in which the glow signal decays out

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at ambient temperature. But those glow signals will not be suited for the purpose, as its decay is too rapid for measurements. The other conditions which have to be taken into consideration for the glow peak to be used as accident dosimetry are sensitivity and linearity for absorbed dose as is the case with normal dosimetry.

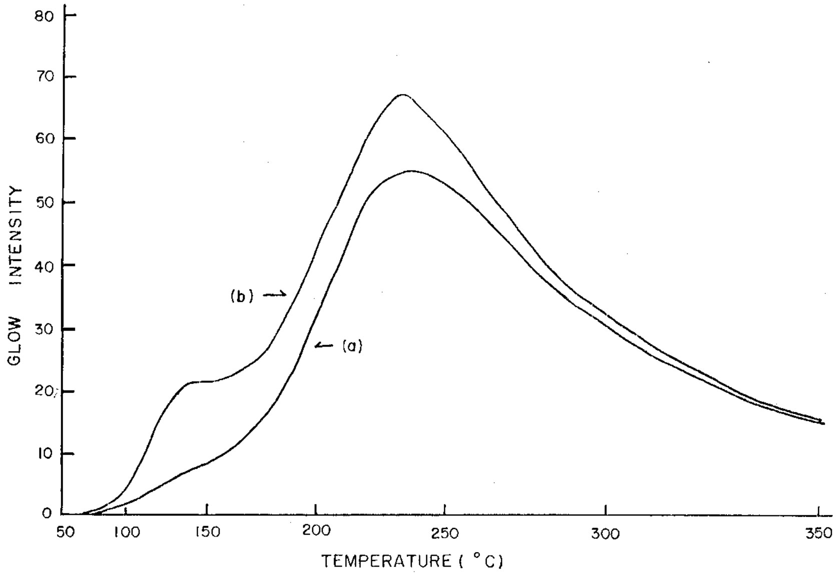

Fig. 1. Glow curve recordings of quartz fraction from sands: (a) natural sample; (b) sample irradiated with ^{60}Co for 500 R.

Considering the conditions mentioned above, material chosen as samples for the present experiments were colorless minerals contained within sands and soil. The grains of the colorless mineral separated by the magnetic method were again separated into quartz and feldspar by means of a method of selectively staining[6]. The glow curves for the quartz sample obtained from sands are illustrated in Fig. 1. The two broad glow peaks at about 140°C and 240°C are prominent in both of the glow curves which are obtained using the natural sample and the natural sample irradiated with ^{60}Co gamma-rays. These two glow maxima responded linearly with the absorbed dose to the range of 1×10^4 R, but they had not so high sensitivity. Also, the glow curves for the feldspar fraction obtained from the same sands are shown in Fig. 2, having an identical figure with that of the sample from soil. The glow curve for the natural sample irradiated with ^{60}Co gamma-rays exhibited the two broad glow maxima at approximately 140°C and 230°C. The glow curve recordings for the sample were taken five days after it was irradiated. In the former glow maximum the glow singnal had linearity and high sensitivity for the absorbed dose, and it was 130 times larger than that of quartz contained within the same colorless mineral in the susceptibility for radiation. This fact supports the suggestion that feldspar fraction is more useful than quartz fraction as phosphor for accident dosimetry.

In the glow curve for the natural sample the glow maximum at the low

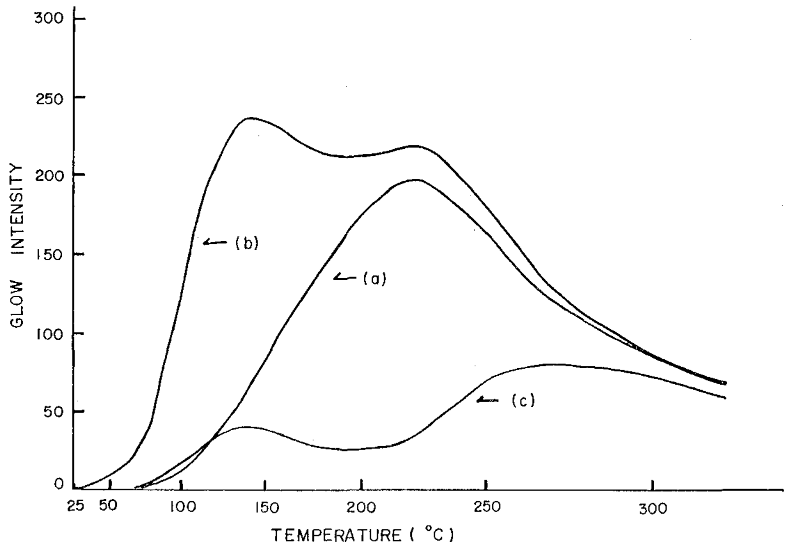

Fig. 2. Glow curve recording of feldspar fraction from sands: (a) natural sample; (b) sample irradiated with ^{60}Co for 500 R; (c) sample irradiated with ^{60}Co for 100 R after 450°C heat treatment for 5 min.

temperature part is extremely lower in intensity as compared with the case of artificial irradiation. Such difference observed in two glow curves arises from the decay of electrons of shallow traps at ambient temperature. The glow curve for the sample irradiated with ^{60}Co gamma-rays after 5 minutes' heat treatment at 450°C is also illustrated in Fig. 2. When the sample is heated up to 450°C, all the trapped electrons are ejected from their traps by thermal agitation and the glow falls to zero, so that the glow intensity resulting from the artificial irradiation after heating gives the thermoluminescence susceptibility of the glow peak.

An appreciable decay of the excited glow signal for the sample just after the irradiation was observed for the about 140°C glow maximum at room temperature. This maximum could be separated into the two peaks, 110°C and 140°C, by means of the difference of their decay: the decay of the 110°C peak was so rapid as the fall of about 80% occurred for a week. On the other hand, the rates of decay for the 140°C peak were 8% per day and 30% per week. Moreover, the linearity between dose and glow intensity for the 140°C peak was examined by employing a known dose of ^{70}Co gamma-rays. As the results, the response of this peak was linear over the range 50 to $\sim 10^5$ R. On the basis of these data, it seemed resonable to assume that the 140°C peak is desirable for accident dosimetry. The problem remained yet to be sloved about this dosimetry is that the intensity of natural glow signal for the 140°C peak is an unknown amount in the case of accident because of overlapping of accident radiation, but the susceptibility obtained by the method mentioned above and the glow intensities caused by various known amount irradiation for the sample might enable us to solve it.

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